AS-INTERFACE

THE COMPENDIUM

Technology and Function ASi-5

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READING SAMPLE

The timing between master and device is important for frame synchronization. How precisely the device synchronizes with the master is crucial. After losing synchronization or after the startup procedure, the device's receiver takes three frames to synchronize with the master *(figure 18: Device synchronization with the master signal)*. Then, the device responds during the appropriate time slots.

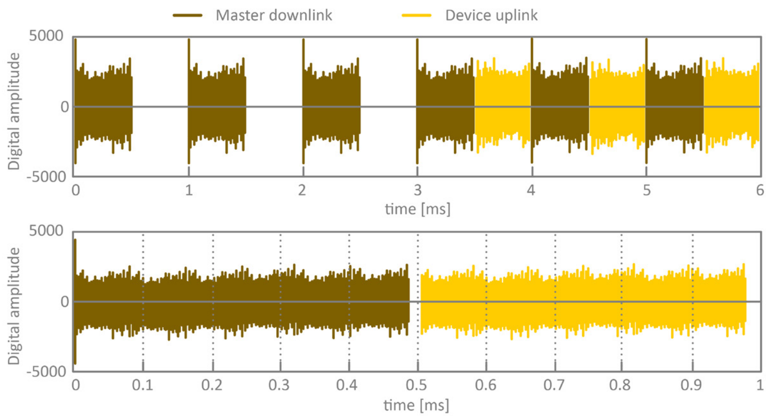
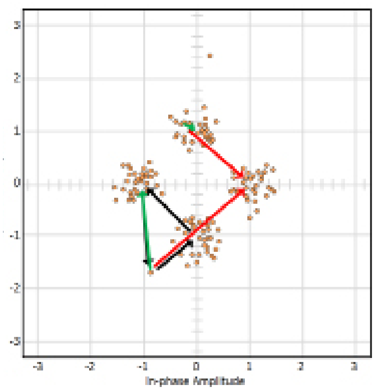


Figure 18: Device synchronization with the master signal

1.9 Relevant system values

SNR, metric, RSSI, Crest factor, RX gain, TX gain

The signal-to-noise ratio (SNR) and the metric of the received data message effect the evaluation of the transmission. The DQPSK symbol can be evaluated in the SNR through the phase error that occurs between two consecutive QPSK symbols. These values are recorded in the MDS and posted for evaluation. The metric examines each transmission channel for phase errors in the modulation of symbols to be transmitted *(figure 19: Visualization of the metric)*. This determines the carrier frequency allocation at system start. The allocation is decided on the smallest deviation from the metric value. Selection of the transmission channels between master and individual devices is not based on the best SNR value but the so-called minimum metric. Here, if the deviation of amplitude and phase of QPSK symbols is too large, the evaluation of the data telegrams must be discarded. This is the only way to guarantee the smallest error rates for decoding. This is why minimum deviation of the phase position is so crucial. The channel encoder adds check bits to the information bits to be transmitted. These check bits are calculated based on content. In the receiver, this redundancy is evaluated in the channel decoder to correct bit errors. Subsequently, by comparing the received with the decoded data, a metric is calculated that provides a measure of the reliability of the decoding.



Decoding: Ideal signal pulses are sent and impacted by noise.

→ Received signal pulses impacted by noise are safely detected.

Correct decoding: Correct signal pulses remain unchanged, incorrect signal pulses jump back to the receiver.

→ Considerable contributions to the metric only through strongly noise-impacted signal pulses.

Incorrect decoding: Correct and incorrect signal pulses sometimes jump to other locations.

→ A correct (just slightly noise-impacted) signal pulse jumping to another signal location significantly enhances its metric.

→ Incorrect signal pulses are strongly impacted by noise and therefore have a relative high metric contribution.

Figure 19: Visualization of the metric

An additional criterion for the allocation of transmission channels is the received signal strength indication (RSSI), i.e., the size of the amplitude of the carrier frequency in the signal spectrum. The distance between the master and the devices effects the signal level. The same applies to the location of the power supply in the electric circuit. RSSI is used to evaluate the received signal in the downlink or uplink phase. Once a sufficiently suitable value has been reached, the number of transmission channels and the crest factor can be calculated. The crest factor describes the difference between the average value of a signal level and the potential peak value for the transmission. This value is calculated to prevent analog and digital converter overload. There are different reasons why the signal level fluctuates. One potential reason is the topology of the signal chain, i.e., cable lengths, number of devices, position of the power supply and data volume *(figure 20: Impact of the signal level and the network position)*.

Example: Transmisson level for different line lengths

50 m line, master at the beginning, 20 devices separated on the line, MP at the end of the line

150 m line, master at the beginning, 20 devices separated on the line, MP at the end of the line

200 m line, master at the beginning, 20 devices separated on the line, MP at the end of the line

Trasmission level depends on the line position

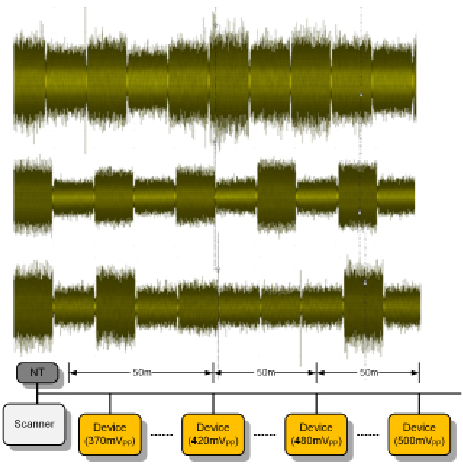


Figure 20: Impact of signal level and network position

Control of receiving and transmission gain (RX/TX gain) ensures ideal adaptation of the communication to the network specifics. This leads to optimum RSSI. After recording the signal amplitude of the transmission channel, the

RX gain is adjusted through automatic gain control (AGC). For the adjustment of the devices' TX gain, it is important that the sum of the signals of all transmitting devices does not exceed an average value to prevent master-receiver overload. This results in the following dualism: A device with good reception only requires low transmission power to be evaluated by the master. A device with poorer reception must transmit with higher power to prevent data loss. *Figure 21: Interdependencies of RX/TX gain* illustrates the interdependencies of the RX gain setting on the devices' TX gain.

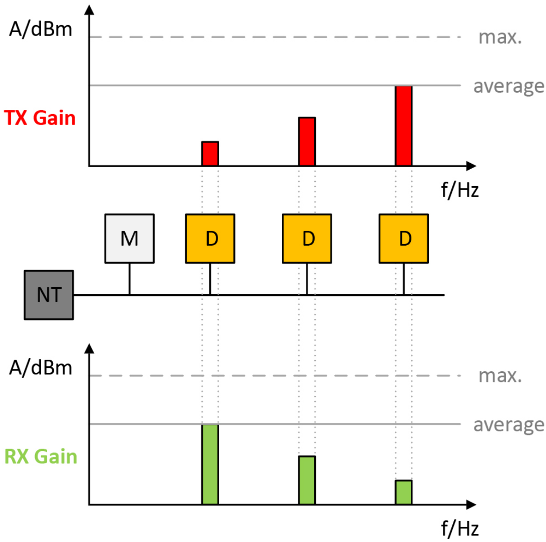


Figure 21: Interdependencies of RX/TX gain

Gain settings																
RX_gain	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
TX_gain	15	15	15	15	15	10	7	5	3	2	1	0	0	0	0	0

Table 2: ASi-5 TX and RX gain settings

In summary: In flexible network topologies, location-dependent and frequency-selective transmission modes are applied:

- OFDM orthogonal frequency-division multiplexing with DMT
- Access master and devices by carrier assignment (DMT-A)
- Directional separation by time division duplex (TDD)
- Adaptive signal amplification: transmitter and receiver adapt to the network

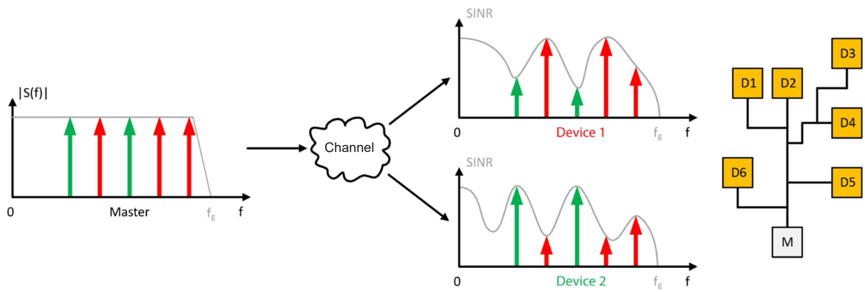


Figure 22: Signals in the network topology

1.10 Communication Channels

ASi-5 offers two different, independent types of communication channels, the transport channel (TC) for regular transmission of process data and event flags, and the acyclic management channel (AMC). The AMC operates at unspecified intervals. The TC is responsible for the communication of commands, parameters, or events.

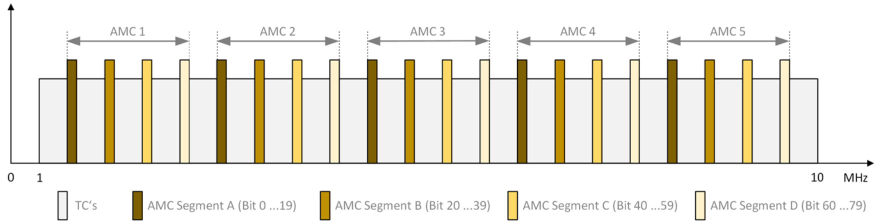


Figure 23: TC/AMC carrier distribution

The transport channel (TC) consists of redundant carrier frequencies to operate in industrial environments with high electrical interference. These carriers are grouped in an ASi-5 subcycle. The subcycle is initiated by a so-called trainings sequence and its downlink contains the information exchange from the ASi-5 master to the ASi-5 devices. The uplink reverses the communication direction, i.e., from the devices to the master. Up to four subcycles using time division multiplexing form an ASi-5 cycle where 16-bits data word length process data can be transmitted as a telegram. To achieve greater bandwidth in communications, master and devices can operate multiple channels simultaneously – a process known as channel bundling. This bidirectional data exchange omits the request-response sequence. Individual bits in a telegram that are not used for recurring data exchange are open for an on-request data service (ORDS) of the acyclic management channel (AMC).

The AMC provides communication channels for all ASi-5 devices and ASi-5 masters. Data of additional services are safely separated from process data. This data is sent or requested via on-demand data communication (ODC) using an ORDS. ORDS telegrams are transmitted as 80-bit data words on four parallel carrier frequencies during one subcycle. The AMC is organized according to a master-to-device ratio. The device responds to the master's request in the next subcycle after the request. If there are no requests directed to the master, it sends general status requests to the devices. In the AMC, carrier allocation and carrier changes are recorded and managed during malfunctions. This is followed by the recording of diagnostics data and the provision of firmware updates.